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Innovative processes to recover base metals and CRM  
from low-grade and complex ores



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## INTMET

Integrated innovative metallurgical system  
to benefit efficiently polymetallic, complex and  
low-grade ores and concentrates.

The EU funded project "Integrated innovative metallurgical system to benefit efficiently polymetallic, complex and low-grade ores and concentrates – INTMET" deals with the ambitious task to recover valuable metals – base metals as well as CRMs – from low-grade ores and difficult ores that are abundant in Europe.

INTMET Project applies the "Mine-to-Metal" concept to produce in the mine Cu, Zn, Pb, Ag and other refined metals under sustainable conditions, treating polymetallic bulk concentrates

through innovative hydrometallurgical solutions based on atmospheric leaching, pressure leaching and bio-leaching, jointly with novel, more effective metals extraction techniques.

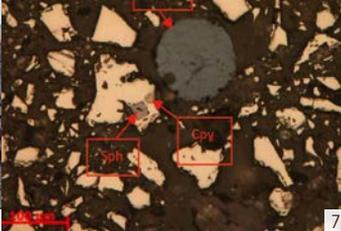
Newly developed processes have undergone positive economic and ecological evaluation as well as LCA and Health and Safety assessment. Several potential industrial applications have been identified and INTMET's results shall now be shared with the public. For more information and results please visit the project website [www.intmet.eu](http://www.intmet.eu).

1 - 5 Laboratory testing equipment for flotation, leaching and metal recovery

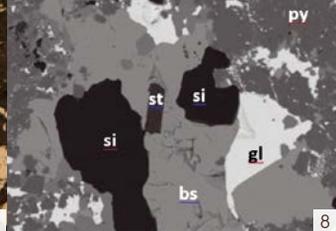




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6 - 8 Samples: Collection and Microscopy Images

## RAW MATERIALS SAMPLING AND CHARACTERIZATION

Four materials obtained from mineral deposits from CLC, KGHM, BOR and Somincor were sampled and characterised. These included polymetallic ores and concentrates, complex or low-grade copper ores and concentrates and pyrite concentrates. Here the delivery of samples for experimental testing was also coordinated.

Regarding flotation tailings and metallurgical wastes as secondary raw materials, limitations related to polymetallic low-grade and complex ores to achieve high efficiency recovery of valuable metals (Cu, Zn, Pb, Ag) and critical raw materials (Co, In, Sb) have been overcome.

## ENHANCED PERFORMANCE FLOTATION PROCESS

This activity developed the necessary technology for bulk concentrate production and provides samples for lab-scale and pilot testing. Main areas of activity were comminution and flotation improvements and production of samples from the developed processes.

Newly developed flotation reagents and microwave techniques have been applied. Additionally, pilot plants have been established to confirm results and produce samples for further testing activities. Electrical pulse fragmentation has been tested as a re-concentration technique. The potential energy saving is going to be evaluated.

9 - 12 Flotation Pilot Plant Equipment: Flotation Cells, Ore feed system & Grinding Mill



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## DEVELOPMENT OF INTEGRATIVE ATMOSPHERIC LEACHING PROCESS

Atmospheric leaching applied on bulk concentrates or middlings is one promising key technology for efficient metals recovery from low-grade, complex and polymetallic ores proposed by INTMET.

Obtained results at lab and pilot scale have shown the high recoveries as expected (e.g. 94% Cu and 95% Zn recovery). It can be stated that a new technological approach has been developed to treat efficiently reserves of polymetallic primary sulphides by means of hydroprocessing.

## DEVELOPMENT OF INTEGRATIVE PRESSURE LEACHING PROCESS

High temperature pressure oxidation is a well proven process for Ni, Au and Zn production. A semi-commercial alternative process for Cu is currently under development - pressure oxidation in an autoclave at temperatures from 135°C to 210°C destroying sulphides rapidly at leach times lower than 60 minutes - releasing base metals into solution for further recovery. INTMET proposes this technology as an efficient way to recover base metals from bulk concentrates and middlings. Lab as well as pilot results obtained showed high Cu and Zn yields (Cu 95%, Zn 99%).

13 Atmospheric Leaching Pilot Plant

14 Pressure Leaching Pilot Plant



**15 - 17** Mintek Bioleaching Reactors – BOR Bioleaching Pilot Plant, small 1l/day, big 20 l/day

## DEVELOPMENT OF INTEGRATIVE BIOLEACHING PROCESS

Bioleaching is a process described as being “the dissolution of metals from their mineral source by certain naturally occurring microorganisms”. The bioleaching performance on four polymetallic samples was assessed by means of testing and detailed steady state mass balances. The results indicated a maximum extractions achieved of 85% Cu, 75% Zn, 90% Pb, 90% Au and 80% Ag.

## VALORISATION OF TAILINGS, WASTES AND EFFLUENTS

The project intended to limit the amount of wastes and effluents by valorising these streams using best tailored technologies. Flotation tailings, wastes materials and effluents are processed to recover iron, non-ferrous metals, CRMs and sulfuric acid. Obtained results showed the high potentiality to integrate the studied technologies improving the economy and the environmental footprint.

**18 - 19** AGQ: Samples before and after treatment

**20 - 21** IMNR: Potassium sulphate obtained from mining wastes



## TECHNOLOGIES ASSESSMENT AND PROJECT EVALUATION

INTMET hydrometallurgical technologies are specifically designed to provide a suitable solution to every application. The developed technologies can deal efficiently with feed materials such as bulk concentrates and low-grade concentrates containing low tenor of base metals and precious metals, which cannot be processed in existing refineries. For instance, tested polymetallic concentrates samples from several mines in Europe ranged: 2-5% Cu, 5-15% Zn, 3-10% Pb, 50-500 ppm Ag.

Developed INTMET hydrometallurgical technologies can be an advantageous alternative to conventional processing technologies, allowing:

- a) to increase 30-50% overall metals recovery in comparison to actual operations,
- b) to process low-grade and complex ores containing impurities such as Hg, Sb, As, etc.
- c) to produce in-situ refined metals (commodities),
- d) to recover additionally some critical materials (e.g. In, Co, etc.),
- e) to rise mineral reserves, reducing the cut-off, in definitive, to achieve a more robust and sustainable mining business.

- 22 Open-pit mine Cobre las Cruces, Spain
- 23 INTMET consortium meeting, February 2018, Bor, Serbia

Final economic and environmental assessment have been performed for several case studies based on mines located in Europe, providing in general rather positive economic results; for example:

Hydrometallurgical plant treating from 0.6 to 1.0 million tpa of bulk concentrate to produce 15-25,000 t/y Cu metal, 40-60,000 t/y Zn metal, 30-80,000 t/y Pb metal and 50-100 t/y Ag.

Internal rate of return, IRR, varies from 14 to 27%, depending on metal production value. Net present value, NPV, ranges 125 to \$325 million, depending on specific conditions. Applying sustainable technologies with minimum footprint because it is not necessary to transport concentrates and not any airborne emission is generated.





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